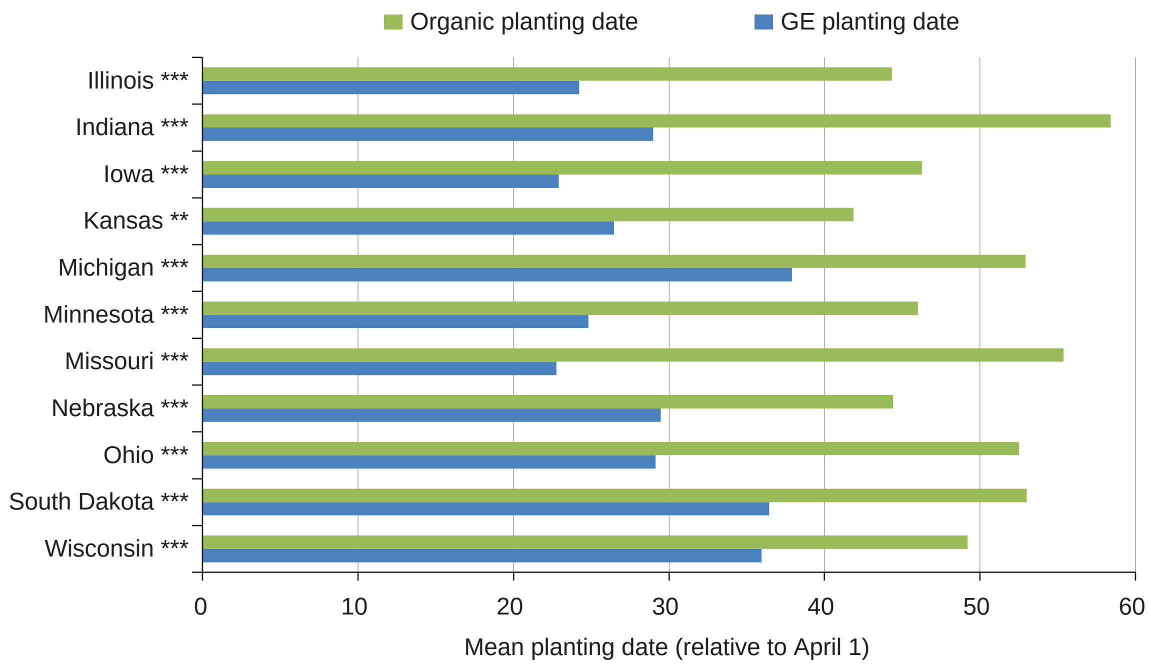
Exhibit G-2: Daniel Hellerstein et al., Agricultural Resources and Environmental Indicators, 2019, EIB-208 (May 2019), Part 2 of 2

Figure 2.13.3

Certified organic corn was planted later than genetically engineered (GE) corn in 2010 to avoid cross-pollination

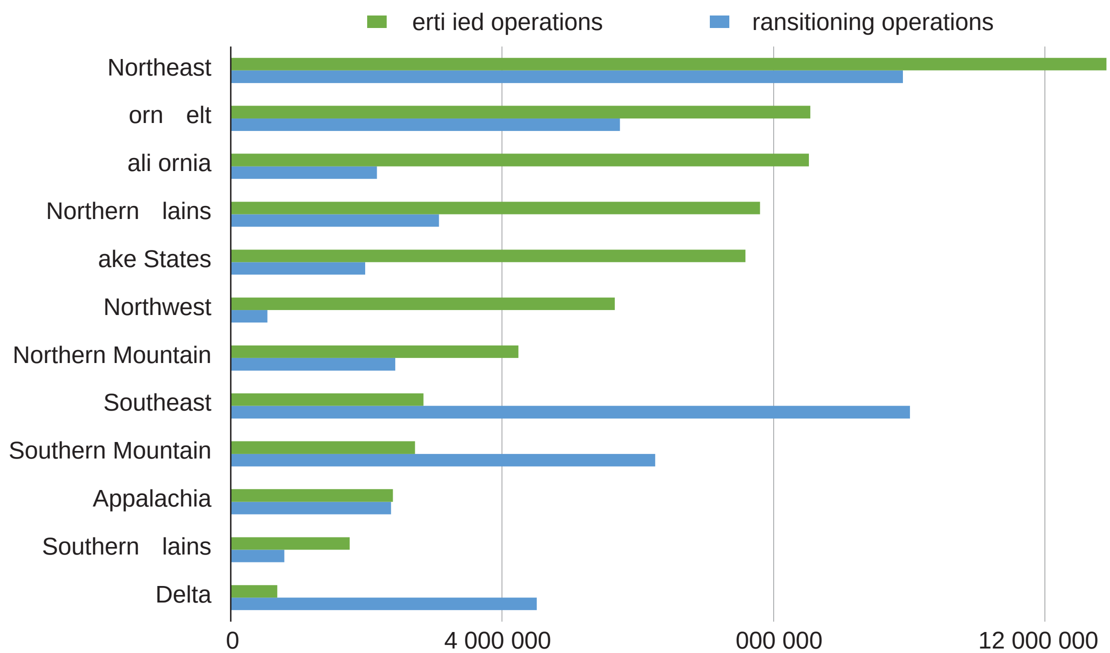


Note: Asterisks denote a statistically significant difference between the GE and organic planting date means at the 5-percent (**) and 1-percent (***) levels.
Source: USDA, Economic Research Service using data from USDA's 2010 Agricultural Resource Management Survey Corn Survey.

Since the early 2000s, USDA and Congress have widened access for organic and transitioning producers to conservation, risk management, and other farm programs. The 2008 Farm Act, for example, expanded USDA's Environmental Quality Incentives Program (EQIP) to include conservation practices related to organic production, as well as those related to conventional production. Congress designated lower payment caps for the EQIP Organic Initiative than for the regular EQIP program, although organic and transitioning farmers compete against a smaller pool of applicants and can also choose to enroll in the regular program instead. Under the Organic EQIP Initiative, USDA provided more than 6,800 farms across the country with $115 million in assistance between 2009 and 2016 to help producers implement conservation practices on organic and transitioning farms (fig 2.13.4). This program may be particularly useful for transitioning farmers who have not already adopted many of the conservation practices used in organic production.

Figure 2.13.4

Environmental Quality Incentives Program (EQIP) funding for organic and transition practices, 2009-2016



Note: Northeast = CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, and VT. Appalachia = KY, NC, TN, VA, and WV. Southeast = AL, FL, GA, and SC. Lake States = MI, MN, and WI. Corn Belt = IL, IN, IA, MO, and OH. Delta = AR, LA, and MS. Northern Plains = KS, ND, NE, and SD. Southern Plains = OK and TX. Northern Mountain = ID, MT, and WY. Southern Mountain = AZ, CO, NV, NM, and UT. Northwest = OR and WA.
Source: USDA, Economic Research Service using EQIP data (2009-16) from USDA, Natural Resources Conservation Service.

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Chapter 2.14—Manure Management

Nigel Key and Stacy Sneeringer

- In 2012, manure was applied to over 22 million acres in the United States, or 2.6 percent of all cropland and pastureland.
- About 78 percent of hog producers applied manure or litter on their own land, compared to 95 percent of dairies and 52 percent of broiler operations.
- About 54 percent of hog producers, 41 percent of dairies, and 66 percent of broiler operations had a nutrient management plan (2009-11) for balancing the quantity of manure and fertilizer nutrients applied to farmland with the quantity of nutrients taken up by crops.

Manure management—how manure is captured, stored, treated, and used—affects the profitability of livestock operations and can influence environmental quality. Manure contains nutrients—such as nitrogen, phosphorus, and potassium—that can reduce crop production costs by substituting for commercial fertilizer. However, overapplying manure nutrients to cropland can increase the risk that these nutrients flow into surface water. Nutrients from manure and fertilizer that are not taken up by plants can run off into surface water where, in sufficient concentration, they can harm plant and marine life. Agriculture is a major source of the nutrient pollution causing harmful algal blooms and hypoxic "dead" zones in several water bodies, including the Chesapeake Bay, Gulf of Mexico, and the Great Lakes. Because manure harbors a wide variety of microorganisms that can be pathogenic to animals and humans, it must be properly contained and managed. How manure is managed can also affect local air quality (haze, small particle concentrations, odor) and greenhouse gas emissions.

Managed livestock waste accounts for about 13 percent of U.S. agricultural greenhouse gas emissions. The decomposition of manure stored in lagoons, ponds, tanks, or pits produces carbon dioxide and methane, each greenhouse gases. When manure is handled as a solid or deposited on fields, it tends to produce much lower greenhouse gas emissions. Lagoon and pit manure handling systems that emit relatively large amounts of methane, a potent greenhouse gas, are common on dairy and hog operations.

Manure Management Policies

Multiple local, State, and Federal policies and regulations are designed to mitigate the environmental harm from animal manure. In 2003, the U.S. Environmental Protection Agency revised Clean Water Act regulations for controlling runoff of manure nutrients from the largest animal feeding operations. The regulations now require operations designated as Concentrated Animal Feeding Operations (CAFOs) and discharging manure effluent to seek National Pollutant Discharge Elimination System (NPDES) permit coverage. CAFOs with NPDES permits must have a nutrient management plan (NMP) that identifies practices to ensure the agronomic use of nutrients. Important components of an NMP include soil and manure testing for nutrient content, balancing farm-available nutrient resources with farm crop needs, and monitoring the operation's total nutrient balance to account for nutrients generated, field-applied, and moved offsite. Enforcement of the Federal CAFO rules falls largely to individual States.

Odor from livestock operations has been a source of friction in many agricultural communities, and several States have adopted odor regulations. These State policies may contain odor standards or require management methods such as separation distances, odor plans, or "good neighbor practices." Several States include odor stipulations in their general permits for livestock operations.

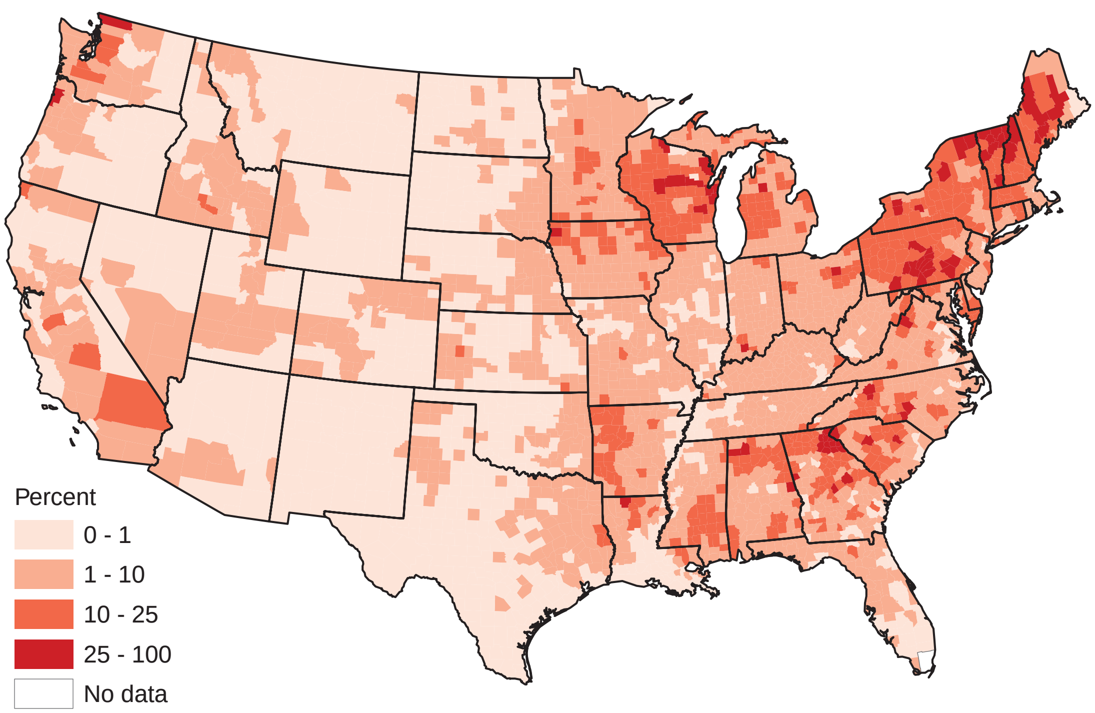
To help defray the costs of meeting environmental regulations, producers can apply for financial assistance from the USDA's Environmental Quality Incentives Program (EQIP). Financial assistance provided by EQIP may be used to help develop and implement a nutrient management plan, construct appropriate animal and manure handling/storage facilities, or transfer and apply manure to land in an approved manner.

Manure Management on Hog, Dairy, and Broiler Operations

Manure is applied to some cropland throughout the United States. According to the 2012 Census of Agriculture, manure was applied to over 22 million acres in the United States, which represented 2.6 percent of total cropland and pastureland. The application of manure to cropland was most prevalent in regions with high concentrations of livestock production including the Northeast, Upper Midwest, and Southeast (fig. 2.14.1).

Figure 2.14.1

Percentage of crop and pasture acreage on which manure is applied, by county, 2012



Source: USDA, Economic Research Service using data from the 2012 Census of Agriculture.

Manure in hog and dairy operations is usually collected and stored in lagoons, pits, or tanks. Lagoons are large earthen containment structures into which manure and wastewater is flushed and maintained in liquid form until removed. Manure pits are often located under hog production facilities where, in the typical system, manure drops into pits through slatted floors and is stored in a slurry form until removed. These storage structures hold the manure until it can be land-applied on the same farm or nearby farms to meet crop nutrient needs. Technologies for land application include liquid/slurry manure spreaders that may or may not incorporate manure into the soil, and irrigation systems that spray or spread the liquid manure solution on nearby fields.

The different systems for manure management have very different impacts on the nutrient content of the manure, primarily nitrogen, and thus on the amount of land needed to spread manure. For example, handling manure in pit or tank storage and using slurry spreaders to inject the manure into the soil manages the manure for its potential fertilizer value. This system is designed to retain manure nitrogen for crop use, and thus it requires more land on which to apply the manure if the operation is following a nitrogen-based nutrient management plan. In contrast, handling manure from lagoon storage and distributing it with irrigation increases the release of nitrogen into the atmosphere, reducing the manure's nitrogen content and requiring less land for application.

On broiler operations, manure is typically collected along with bedding material (e.g., wood shavings) and feathers when houses are cleaned. The mixture of bedding and manure (called litter) is relatively dry, which makes it easier and cheaper to store and transport than hog and cow manure. When a poultry house is cleaned out, the litter can be immediately spread on a field or stored for later applications. When stored, litter is often kept in a shed to reduce rainwater runoff of nutrients.

On some livestock operations, manure is directly deposited on the fields by grazing animals. However, on most confined livestock operations, manure is collected and then spread on the operation's own fields or removed from the operation and spread on nearby farmland. The amount of manure that is applied onfarm versus removed depends on how much cropland the farm controls, the nutrient uptake of the crops grown on the farm, and the demand for manure on nearby farms.

The USDA's Agricultural Resource Management Survey (ARMS), which focuses on different types of livestock producers every 4 or 5 years, provides detailed information about farm production practices, including manure management.[1] Based on the 2009 ARMS, 78 percent of hog operations applied manure on their own operations—with about an equal share applying in solid, liquid, or slurry form (table 2.14.1). The average hog operation applied manure to 105 acres of land, which represents about a fifth of the average operation's cropland. About 21 percent of hog operations removed manure from their operations, with most giving it away. Only 5 percent of hog farms sold manure, reflecting weak demand for hog manure in regions where hogs are produced.

Dairy operations were more likely than hog operations to use manure on their own operations. In 2010, 95 percent of dairies applied manure onfarm, mostly in solid form. The average dairy applied manure to 156 acres, which represents about half of the dairy sector's average crop acreage. Only 10 percent of dairies removed manure from their operation, again with most of this given away for free.

In 2011, only about half (52 percent) of broiler operations applied manure onfarm; a large portion of broiler growers have no cropland. Growers who do have cropland apply manure at a high rate; on average, manure is applied on over 90 percent of available crop acres. With little cropland for spreading manure, almost three-quarters of all broiler operations removed some manure from their operation in 2011. Broiler litter is relatively valuable. Almost two-thirds of operations either sold manure or exchanged it for services (such as cleaning out the broiler house).

[1]Detailed information about manure management was not collected after 2011.

Table 2.14.1

Manure/litter application and removal on livestock operations, 2009-11

	Hogs	Dairy	Broilers
		Average per farm	
Acres with manure/litter application	105	156	88
Cropland acres	503	316	95
Percent of cropland with manure/litter application	21	49	93
		Percent of farms	
Applied manure/litter onfarm	78	95	52
Solid	29	80	n.a.
Liquid	27	31	n.a.
Slurry	36	20	n.a.
Manure deposited on fields/pasture	4	10	n.a.
Removed manure/litter from operation	21	10	72
Sold manure/litter	5	2	34
Litter given in exchange for service	n.a.	n.a.	31
Manure/litter given away for free	16	7	10
Paid for manure/litter removal	2	1	3

Note: n.a. = Not asked on survey.
Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey, 2009 (hogs), 2010 (dairy), 2011 (broilers).

Manure Nutrient Management Practices

In addition to deciding whether to apply manure onfarm, growers must decide how much manure to apply to their crops. A nutrient management plan (NMP), which can be voluntary or required by statute, specifies a set of nutrient management practices that a farmer should take to match applied manure and commercial fertilizer nutrients with the absorptive capacity of the land and crops. About two-thirds of broiler operations had an NMP in 2011, compared with 54 percent of hog operations (2009) and 41 percent of dairies (2010, table 2.14.2). Manure nutrient testing, a practice required as part of many State-mandated manure management plans, was employed by about a third of hog and broiler operations and 22 percent of dairy operations.

Farmers apply commercial fertilizer to crops in addition to manure if the manure nutrients do not meet the nutritional needs of the crops. Testing the nutrient content of manure can save costs by avoiding the over-application of supplemental commercial fertilizer. About 43 percent of all dairy operations adjusted their fertilizer nutrients, compared to 31 percent of hog operations and 14 percent of broiler operations.

Some hog and dairy operations adjusted the nutrient content of manure via modification to their feed formula or feeding schedule, typically to reduce the nitrogen or phosphorus content of the manure. This allows the same amount of manure to be spread over a smaller amount of land while providing the same amount of nutrients. Adjusting the nutrient content of manure via feed was practiced by a third of hog operations, but only 7 percent of dairy farms.

EQIP payments for manure management were used primarily for installing manure handling and storage facilities, manure hauling, and application or for a nutrient management plan (development, testing, and recordkeeping). EQIP payments were not common: the share of hog, dairy and broiler operations that received these payments ranged from 2 to 4 percent over 2009-11 (see chapter 3.24, “Working Lands”).

Table 2.14.2

Percent of farms with manure/litter management practices, 2009-11

	Hogs	Dairy	Broilers
Has a nutrient management plan	54	41	66
Tested manure/litter for N or P content	37	22	31
Adjusted commercial fertilizer to account for manure/litter nutrients (N or P)	31	43	14
Adjusted nutrient content of manure via feed formula or feeding schedule	33	7	n.a.
Received EQIP payments for manure management	3	4	2

Note: n.a. = Not asked on survey. N = nitrogen; P = phosphorus.
Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey, 2009 (hogs), 2010 (dairy), 2011 (broilers).

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Chapter 2.15—Antibiotic Use in U.S. Livestock Production

Stacy Sneeringer and Maria Bowman

- By the end of 2017, 44 percent of U.S. broiler chickens were raised without any antibiotics.
- Between 2004 and 2015, the share of finishing hogs sold or removed from operations reporting that they *did not know or did not report* whether antibiotics were used for growth promotion rose from 7 percent to 35 percent.
- Use of antibiotics for purposes other than disease treatment is associated with a 1- to 3-percent increase in the productivity of hog and broiler operations.

The animal agriculture sector is a major user of antibiotic drugs for disease treatment, disease control, and disease prevention. These drugs are pivotal for animal health and farm productivity, but many of the antibiotics used on the farm are in the same classes as those used in human medicine. Agricultural use of antibiotics important for disease treatment in human medicine— called "medically important" antibiotics by the FDA[1]—is an increasing source of public health concern. Routine use of antibiotics, in humans or animals, can promote antimicrobial resistance, such that antibiotics fail to contain bacterial infections. The U.S. Centers for Disease Control and Prevention (CDC) estimates that over 2 million people in the United States annually become ill from resistant infections, with at least 23,000 dying (CDC, 2013). Other estimates suggest that by 2050, antimicrobial resistance will result in more deaths than cancer worldwide (Review on Antimicrobial Resistance, 2016). While antibiotics administered to livestock have been linked to human health risks, the extent of these risks remains a matter of debate.

Concerns over antibiotic resistance have led to calls to use the drugs more judiciously in all settings, and to examine alternatives to their use. In 2017, new U.S. Food and Drug Administration (FDA) rules went into effect making it illegal to provide medically important antibiotics in feed or water to livestock for production purposes such as growth promotion (U.S. FDA, 2012 and 2013). These new requirements now compel veterinarians to oversee all use of in-feed or in-water medically important antibiotics in livestock, rather than having some available over the counter. Consumers and major retailers also are increasingly demanding livestock products resulting from animals that never received any antibiotics for any purpose. In response, several major food retailers have placed restrictions on the use of antibiotics for production purposes by their meat suppliers (Pew Charitable Trusts, 2015). Changes in antibiotic use will lead to a series of adjustments in animal agriculture as producers change production practices, with potential repercussions for prices and volumes in livestock markets.

Use of Antibiotics in the Livestock Sectors

Reasons for antibiotic use, extent of their use, who makes the decision to use them, how restrictions on use would be felt in the industry, and how policies could be implemented all depend on the structure and organization of livestock production.

[1]Nonmedically important antibiotics are those not used in human medicine. The predominant type of these is ionophores.

Broilers. Almost all U.S. broiler production is carried out through production contracts between growers and integrators. Integrators own and operate feed mills, hatcheries, and processing plants. They also provide feed, chicks, and veterinary services to growers, who raise the chicks to market weight on their own farms under contracts with the integrators. Integrators dictate feed formulations, including administration of antibiotics.

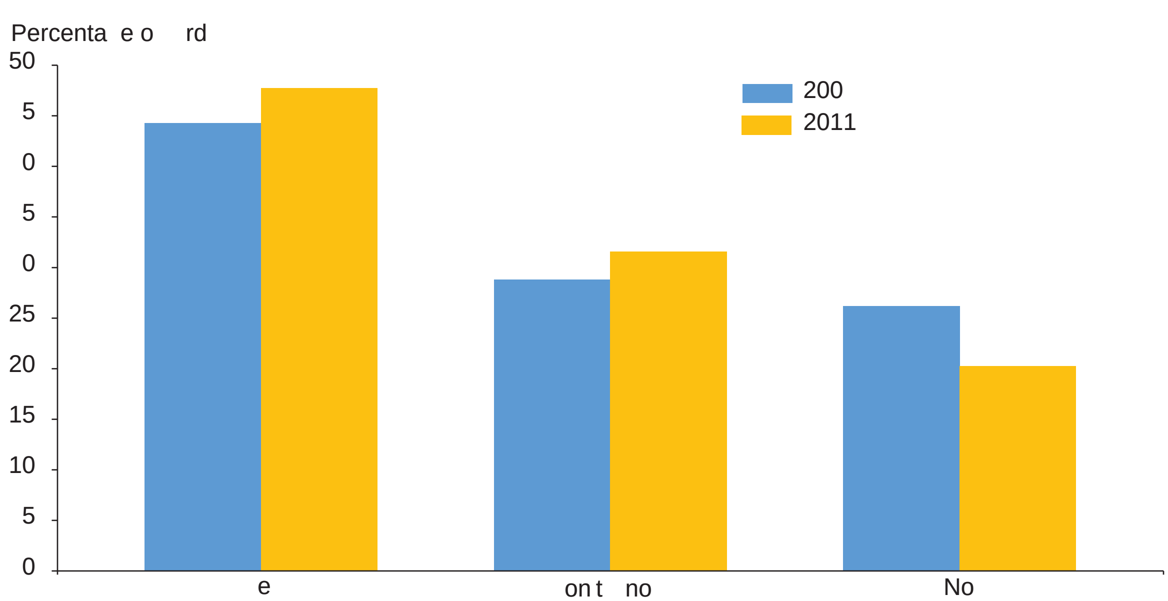
Antibiotics may be used to treat sick birds, and flocks may also be given a course of antibiotics in feed or water to prevent the spread of disease when outbreaks are detected in nearby houses or farms or when cull rates rise within a house. Antibiotics are also often injected into eggs or chicks to improve early viability. Before FDA requirements ended the practice in 2017, medically important antibiotics were fed to broilers to promote growth (U.S. FDA, 2012 and 2013; NRC, 1999).

Between 2006 and 2011, the share of broilers raised *without* antibiotics except for disease treatment rose from 44 to 48 percent. The percentage of birds removed from operations reporting they did not know whether their birds were raised without antibiotics except for disease treatment rose from 29 to 32 percent (fig. 2.15.1). As integrators often supply feed, many growers may not know whether antibiotics are in their feed.

A growing share of broiler production is performed under product lines termed “raised without antibiotics”; in these settings, no antibiotics (including non-medically important ones) are administered for any purpose. Flocks that get sick are treated with antibiotics but sold under a different product line. By the end of 2017, 44 percent of broiler chickens were raised under these ”raised without antibiotics” product lines following the announcements of two leading companies (according to USDA, Agricultural Marketing Service’s *Agricultural Analytics*).

Figure 2.15.1

Percentage of broilers receiving antibiotics only for disease treatment purposes, 2006 and 2011



Note: ARMS asked respondents if they used antibiotics only in the event of illness, the question to which the “Yes” responders were replying.
Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS) broiler survey, 2006 and 2011.

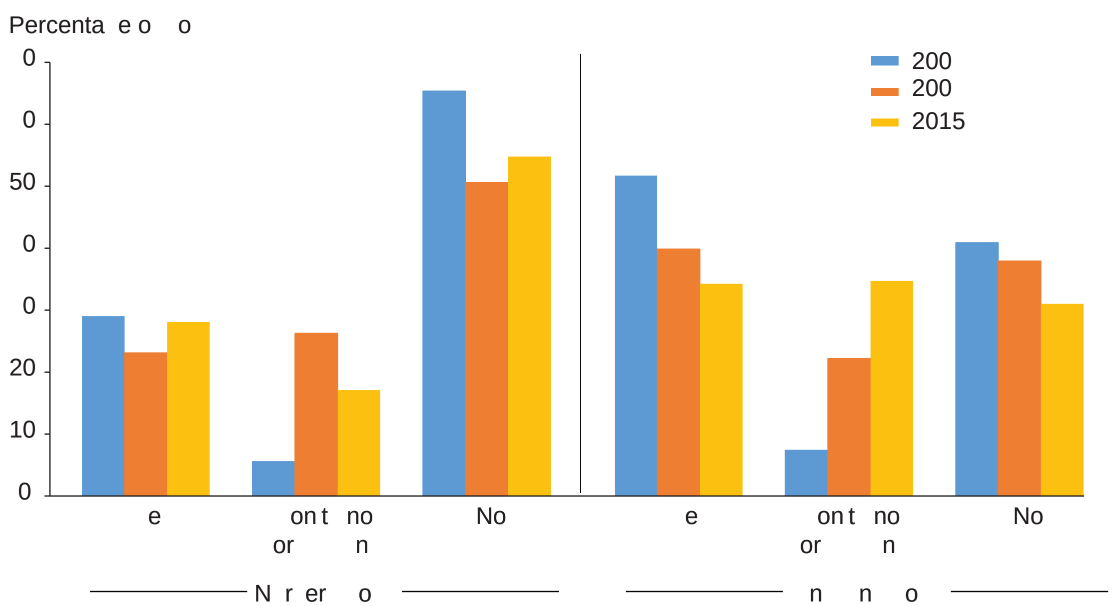
Hogs. Hog production has become increasingly vertically integrated and specialized in terms of the animal lifecycle. Integrators provide contract growers with feed, veterinary services, and animals. Contracted sow operations farrow young pigs, which are shipped to nursery operations. There they are raised to feeder weights and then shipped to finishing operations. After being fed to market weights, integrators either ship the hogs to their own packing plants or sell them to others.

Hogs may be treated for diseases with antibiotics at any point in their lifecycle, but an especially risky time occurs in the pre-weaning and nursery stages. In 2012, 10 percent of pre-weaning piglet deaths were caused by scours (another name for diarrhea), an illness frequently treated with antibiotics. In the finishing stages, respiratory problems are the most prevalent disease-induced causes of death (75 percent); these instances are also treated with antibiotics (USDA, APHIS, 2015).

Before the FDA requirements ended the practice in 2017, antibiotics were fed to both young (nursery) pigs as well as market (finishing) hogs to promote growth. Between 2004 and 2015, the share of *finishing* hogs sold or removed[2] from operations reporting that they *did not* administer antibiotics for growth promotion declined from 41 percent to 31 percent (fig. 2.15.2). Over the same time period, the share of operations stating they did not know—or did not report—whether antibiotics were administered for growth promotion rose by 28 percentage points. This was coupled with a comparable decline in hogs raised at operations reporting that they *did* use antibiotics for growth promotion. Thus, for finishing hogs, producers seemingly became less willing or able to report on their use of antibiotics for growth promotion between 2004 and 2015.

Figure 2.15.2

Percentage of hogs sold or removed receiving antibiotics for growth promotion, 2004, 2009 and 2015



Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey, 2004, 2009, and 2015.

[2]Independent hog producers sell animals. Contracted hog producers have hogs “removed” from their facilities. Hence the phrase “sold or removed.”

Trends for nursery hogs are less easy to interpret. The share of *nursery* hogs sold or removed from operations that *did not* administer antibiotics for growth fell from 65 to 51 percent between 2004 and 2009, but then rose to 55 percent between 2009 and 2015. The share of operations stating that they did not know or report whether antibiotics were administered rose from 6 to 17 percent (2015), while the share of nursery hog operations reporting that they *did* use antibiotics for growth promotion remained around 29 percent. Because of these shifts, it is difficult to tell whether use of growth-promoting antibiotics in nursery pig production rose or fell between 2004 and 2015.

Beef cattle. Beef cattle production can be divided into two stages. On *cow-calf operations*, calves are birthed and raised until weaning. In 2007/2008, nearly 16 percent of cow-calf operations reported adding antibiotics (inclusive of non-medically important antibiotics) to cattle feed to prevent disease and/or promote growth (USDA, APHIS, 2012).

On *stocker, backgrounding, and feedlot operations*, cattle are fed to slaughter weight. Animals are often shipped long distances to these operations. Co-mingling of cattle from various locations increases the threat of disease spread, so animals often receive preventive injections of antibiotics upon arrival. In 2011, a quarter of cattle at large-scale feedlots received injected antibiotics (USDA, APHIS, 2012). Nearly half of cattle at large-scale feedlots received medically important antibiotics in feed (USDA, APHIS, 2013).

Dairy. Unlike hogs or broilers, dairies do not operate under production contracts. Dairy operators often retain female cows for their entire lifecycle, while selling male calves for beef. Antibiotics are used on dairy farms to treat and prevent disease, but they also have been used in heifer rations for growth promotion. Diarrheal and respiratory problems are frequent in preweaned dairy calves. To help prevent these illnesses, dairy operations fed 40 percent of pre-weaned heifers medicated milk replacer in 2014 (USDA, APHIS, 2016a).

After heifers are bred and give birth, they may contract diseases or disorders that are often treated with antibiotics. In 2014, 93 percent of dairy operations provided antibiotics for prevention of intramammary infections between lactation periods (USDA, APHIS, 2016b).

Notably, the FDA has established minimum intervals between the last dose of antimicrobials and the time of slaughter to allow antibiotic residues in meat to reach levels safe for human consumption (U.S. FDA, 2014). Likewise, if dairy cows have been treated with antibiotics, they must be withdrawn for a time before their milk can be sold into the food chain.

Economics of Reducing Antibiotic Use

Antibiotics may reduce the use of other inputs (such as feed) and lower morbidity and mortality. If the gains from using antibiotics outweigh the costs, then antibiotic use can increase livestock productivity and efficiency. Indirectly, antibiotics may influence the scale and type of production; if antibiotics reduce the amount of space needed per animal, then more animals can be raised per square foot.

Reducing antibiotic use may require adjustments to production processes. Farm operators may need to provide more feed to reach production targets, but they may also use other animal drugs, feed supplements, administer vaccines, alter sanitation practices, change genetic lines, or modify housing environments through capital investments. Such adjustments influence the financial outcomes from reducing antibiotic use and may also affect animal health and environmental outcomes.

Reducing use of antibiotics may yield higher production costs, which can lead to higher prices and lower market supply. Use of antibiotics for purposes other than disease treatment is associated with a 1- to 3-percent increase in productivity on hog and broiler operations. The increase in the cost of production from ceasing antibiotic use is estimated to lead to an increase of 1 percent in wholesale prices and a drop in output of less than 1 percent (Sneeringer et al., 2015).

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Group 3: Natural Resources and Conservation

Chapter 3.16—Farm-Level Adaptation to Drought Risk

Steven Wallander and Andrew Crane-Droesch

- Exposure to drought risk varies considerably across the country. In some Western States, agricultural producers experience a severe or extreme drought in 1 out of every 3 years, on average, versus 1 out of 5 years in the Midwest and Northeast.
- Participation in voluntary conservation programs is influenced by regional differences in drought risk. Producers in higher risk regions are more likely to participate in EQIP (Environmental Quality Incentives Program) contracts that include irrigation efficiency improvements or water conservation.
- Irrigation can be an important source of drought resilience, but drought often leads to severe curtailment of surface-water supplies for irrigation. In some areas, irrigators can offset reduced surface-water availability through increased groundwater pumping, which can extend droughts' long-term impacts through depleted groundwater levels.

Drought Risk

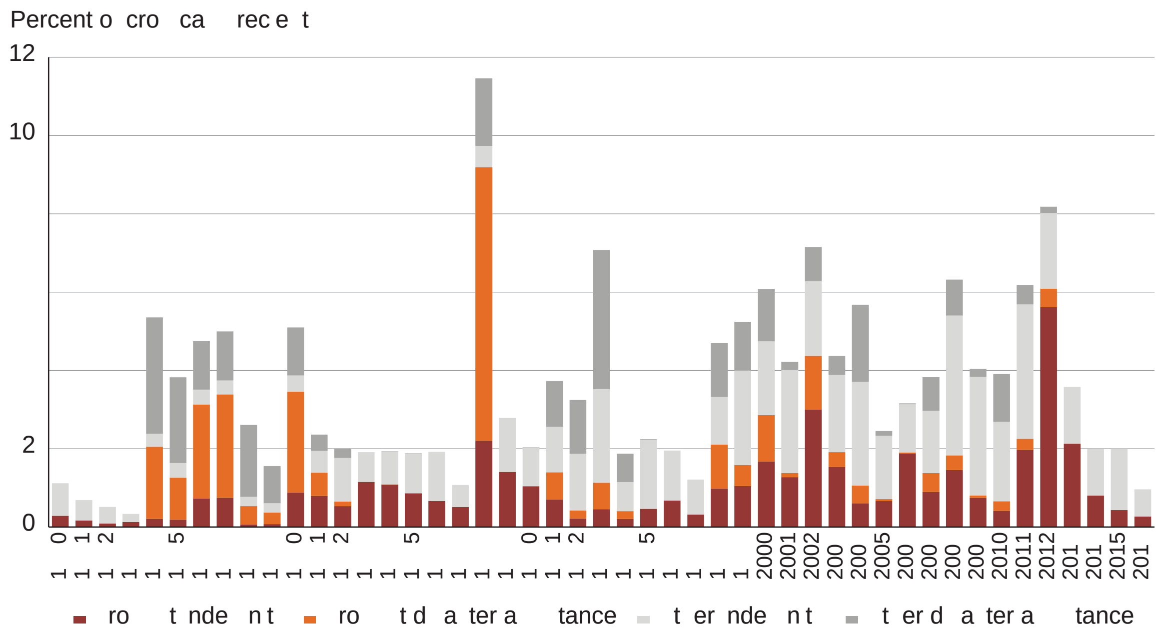
The risk of drought is a concern for agricultural producers throughout the county. Drought—a reduction in water availability due to a combination of low precipitation and high temperatures—can reduce productivity and lead to severe losses in farm income. Droughts are measured both in terms of duration and severity, and their impact can be dependent on their timing.

A variety of policy options address drought, many involving large-scale investments in infrastructure or major changes in water allocation that are beyond the agricultural sector's control (Schwabe and Connor, 2012). This chapter focuses on farm-level decisions that can attenuate the impacts of drought, which can be influenced by existing infrastructure and institutional arrangements.

Drought is the leading driver of production risk in U.S. agriculture (fig. 3.16.1). No other source of production risk—including flooding, early frosts, and pests—is as nationally significant as drought in terms of lost agricultural production and income. A major drought can reduce crop yields, limit planted or harvested acreage, reduce livestock productivity, and increase costs of production inputs such as animal feed and irrigation water.

Figure 3.16.1

Drought is the largest cause of crop insurance indemnities and disaster payments, 1970-2016



Note: Total payments have been converted into percentage of cash crop receipts using ERS annual farm income tables.
Source: USDA, Economic Research Service using cause-of-loss data from USDA's Risk Management Agency and disaster assistance data from USDA's annual reports on Commodity Credit Corporation expenditures.

Regions differ in how frequently they experience severe drought. Some regions, such as parts of the Midwest, Northeast, and coastal Northwest, have experienced severe or extreme drought for about 1 of every 5 years, on average, from 1900 to 2016. Other areas face higher drought risk. For example, areas in the Southwest, Southeast, Northern High Plains, and intermountain West have had severe or extreme drought about once every 3 years (fig. 3.16.2).

Precipitation and temperature vary widely by region, so climatologists measure droughts relative to local climate conditions. For example, the conditions associated with an extreme drought in central Ohio can look like average, non-drought conditions in semi-arid western Kansas. Farmers in different regions tailor their crop choices, production systems, and decisions on inputs (like how much fertilizer to apply) based largely on average weather conditions in their area—which makes them vulnerable when those conditions change.

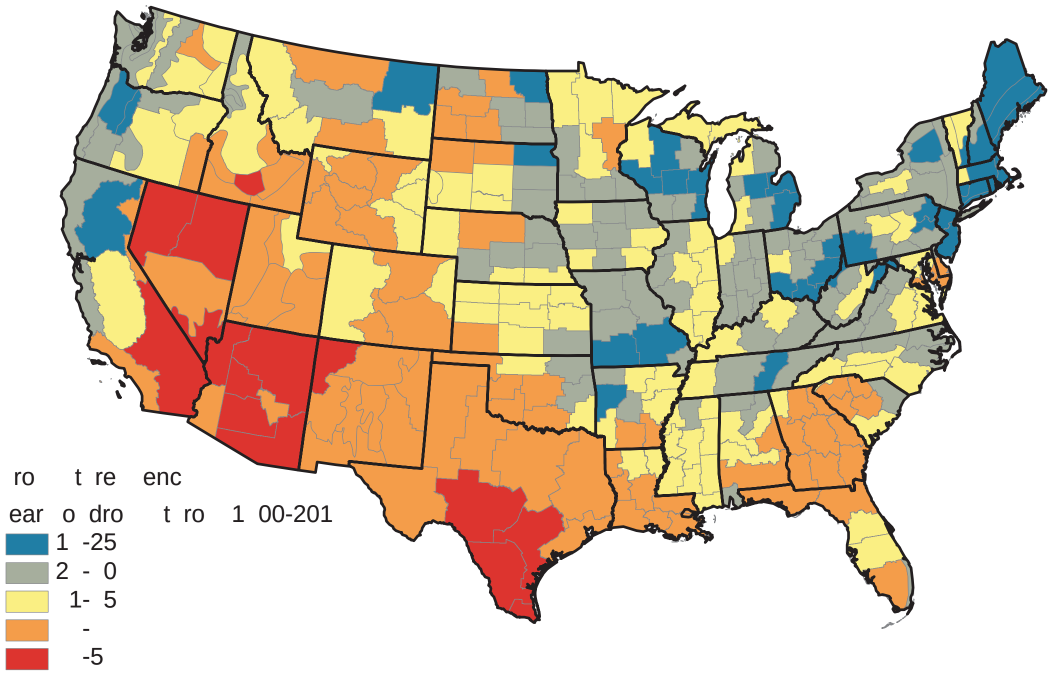
Adaptation to Drought Risk

In general, adaptation is the process of altering behaviors and characteristics to improve suitability to a given environment. For example, increased drought risk stemming from climate change may prompt farmers to alter their production practices or investments.

Adaptive changes are generally taken to minimize damages to livelihoods stemming from adverse events, and/or to capitalize on any opportunities presented. Almost all farmer actions can be viewed as adaptation, because the physical, biological, and economic environment in which farmers operate changes continuously. The likelihood of increased risk and severity of drought—defined both by temperature and precipitation—is one of many factors to which farmers will adapt in coming years and decades (IPCC, 2014).

Figure 3.16.2

Drought risk reflects frequency of severe drought and varies regionally, 1900-2016



Note: Drought frequency is the number of years when at least 1 summer month (June, July, or August) had moderate or worse drought (PMDI ≤ -2.00).
Source: USDA, Economic Research Service using historical data by climate district from the National Oceanic and Atmospheric Administration, Palmer Modified Drought Index (PMDI).

Adaptation may be shortrun or longrun. Shortrun adaptation generally involves minimal fixed or sunk costs and often provides drought remediation for only one or two seasons. For example, shifting planted acreage from a drought-sensitive to a drought-tolerant crop would be a short-term adaptation to increased drought risk. Likewise, a shift *into* drought-sensitive crops would be adaptive for a farmer who is less exposed to drought (if prices of the drought-sensitive crop are expected to increase in response to changes in supply).

Longrun adaptations to increased drought risk will generally be more expensive and less reversible, but sometimes more effective. For example, farmers may buy or sell land in response to changing expectations of its future value, or farmers could install water-saving infrastructure on their farms, such as check-dams on tile drainage systems. ERS research has shown that farmers in higher risk drought regions are more likely to enroll in the Environmental Quality Incentives Program (EQIP) for financial assistance that supports drought-mitigating practices (Wallander et al., 2013).

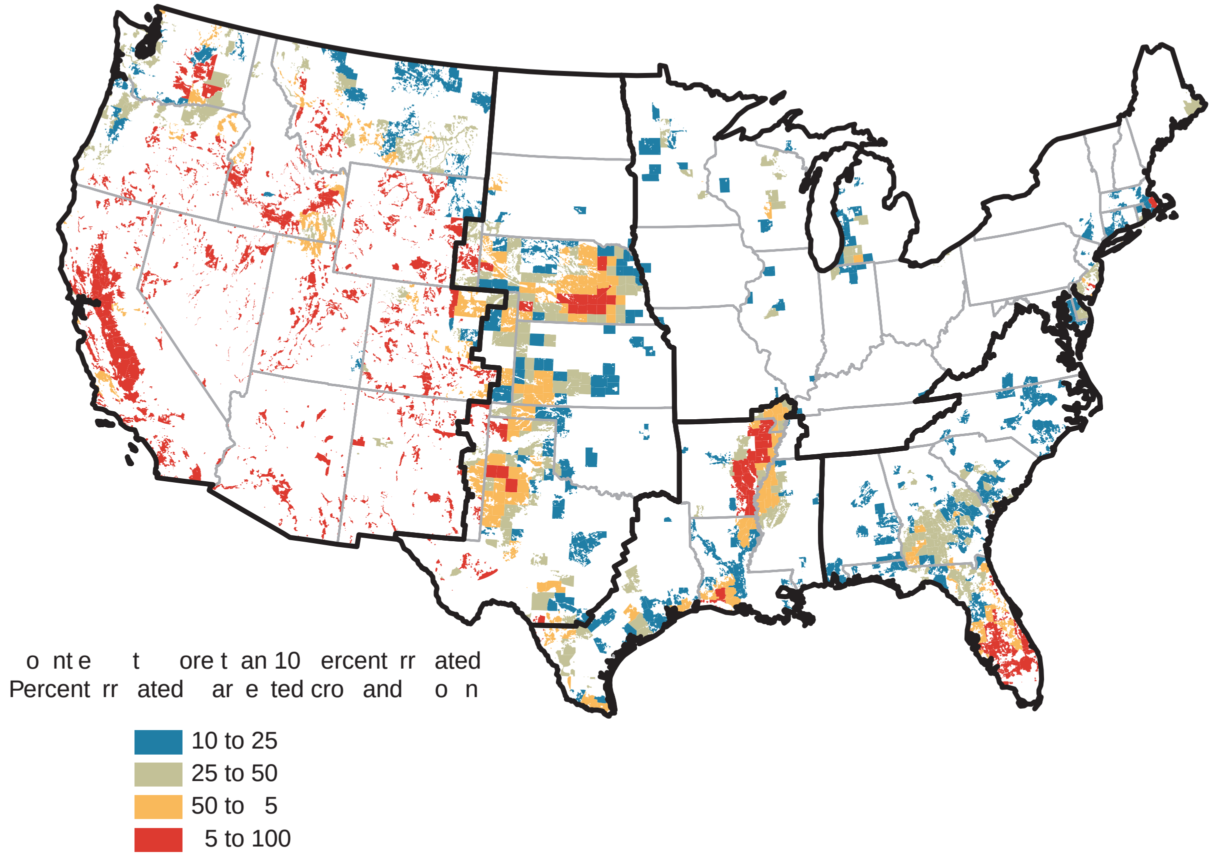
Irrigation and Drought Adaptation

Irrigation can be a straightforward response to drought. When available precipitation cannot meet crop water requirements, irrigators can add water to meet the demand if an adequate water supply is available. However, expanding irrigated acreage as a response to increased drought risk may not be feasible. Irrigation levels are constrained by water availability, which is a function of climate, geology, investments in the infrastructure required to store and transport water, and water allocation institutions. Irrigated

acreage, as a percentage of total cropland, is clustered in particular areas, generally near major rivers, aquifers, and other accessible water sources (fig. 3.16.3).

Figure 3.16.3

Irrigated cropland is concentrated in areas with adequate water supplies, 1998-2013



Note: County boundaries are clipped to show only cropland in order to illustrate the relative extent of irrigation in different regions and the spatial concentration within the Western counties. Only counties with at least 10 percent of cropland irrigated in at least one of the past four census of agriculture reports are included. Some counties are not shown due to missing data values.
Source: USDA, Economic Research Service calculations based on data from USDA, National Agricultural Statistics Service, Census of Agriculture, 1998, 2003, 2008 and 2013.

Irrigated acreage predominates in dry areas and areas with high drought risk. To the degree that climate change and/or competing uses of water reduces the supply of water for irrigation, farmers may adapt by improving their irrigation efficiency, such as by shifting irrigation to evening hours to reduce the amount of water lost to evaporation or investing in more efficient irrigation infrastructure (see chapter 2.10, “Irrigated Agriculture”).

In some places, expansion of supplemental irrigation—where crops are primarily rainfed but water is applied when necessitated by dry spells—may be an effective adaptive response. Such responses are particularly timely amid hot and dry spells during critical crop-development periods, despite sufficient *average* rainfall. Increases in hot/dry spells are consistent with most projections of climate change into the coming century.

Farmers generally have limited control over the availability of groundwater or surface-water reserves for irrigation. Irrigation reduces drought vulnerability in many areas by allowing farmers to augment precipitation where sufficient groundwater is available. In other areas, surface-water irrigation is possible, but its infrastructure is costly. Some irrigators rely almost exclusively on large aquifers, such as the Ogallala Aquifer in the High Plains and the Mississippi Embayment in the southern Mississippi River region. Many of these aquifers have recently been subjected to severe overdraft, which significantly reduces the availability of groundwater as a buffer to drought. In the intermountain West, many irrigators draw on both groundwater and surface-water supplies, which can allow users to apply excess surface water in wet years to replenish groundwater reserves that are overdrafted in dry years.

In California and other Western States, surface-water supplies are highly vulnerable to drought. Reservoir storage systems help economize on irrigation supplies during periods of reduced stream flows, providing a buffer against short-term drought. However, reliance on surface water for irrigation creates its own form of drought vulnerability. Prolonged drought generally reduces the quantity of surface water delivered, compromising farm production systems that depend heavily on surface water for irrigation.

Furthermore, most aspects of water allocation are under the purview of State laws. Many States have established institutions for allocating water rights among competing uses and users based on seniority ("prior appropriation" water rights). When water availability is low, senior water rights holders in those States are first in line for water allocation. Water is delivered fully in order of seniority until allocation limits are reached, and then remaining rights holders receive no deliveries. This makes irrigators with less senior water rights particularly vulnerable during periods of drought. In some areas, States and local water districts have established markets to allow for the trading of water rights.

Tile Drainage and Adaptation

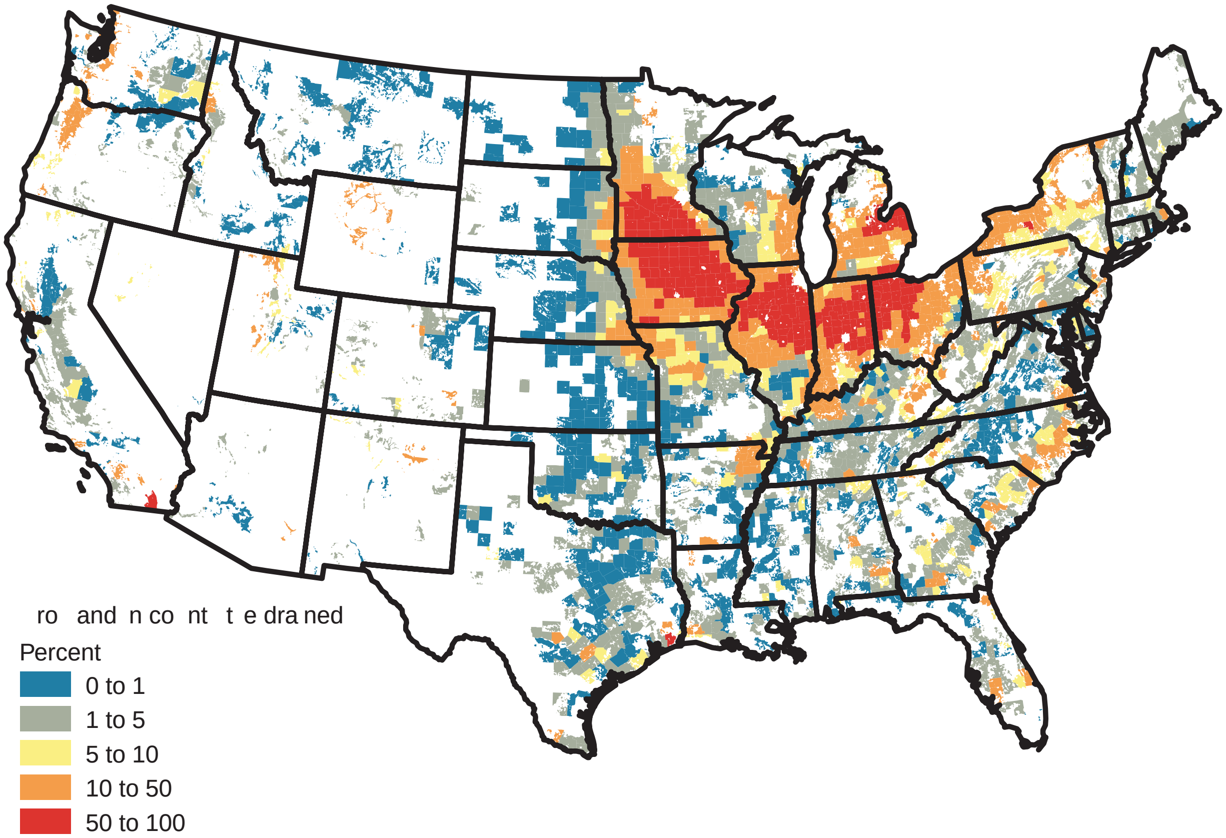
Tile drainage (fig. 3.16.4) has traditionally been installed to address problems of excess water, rather than drought. Tile drains help farmers to quickly remove excess water from the soil profile, allowing them to work the fields and avoid waterlogging. However, major droughts (e.g., 1956, 1988, and 2012) have led to yield losses in areas that are tile drained since these areas do not typically have irrigation. Modified tile drainage may allow some producers to temporarily restrict flow, if they are able to temporarily close or restrict the systems and retain more water in the soil profile as a safeguard against drought.

Soil Health and Adaptation

Many farms may lack the water supply to use irrigation as a drought adaptation strategy, or the slope and soil profile to make tile drainage effective. However, all farms may improve their resilience to drought by investing in soil health.

Soil organic matter provides numerous agro-ecological functions and is a prime indicator of overall soil health (see chapter 3.19, "Soil Health"). Investing in soil health practices that increase soil organic matter can enable the soil profile to retain more water while also improving infiltration and reducing runoff during intense rain events. Effective soil organic matter practices vary by region and production system, but include conservation tillage and cover cropping. Both approaches encourage soil carbon stocks to accumulate faster than their natural rate of decomposition. While the economics of these systems are highly contextual and not fully understood, they may constitute an important adaptive strategy in many areas.

Figure 3.16.4
Tile drainage is most common in regions that typically lack irrigation, 2012



Note: County boundaries are clipped to show only cropland to illustrate the relative extent of irrigation in different regions and the spatial concentration within the Western counties.
Source: USDA, Economic Research Service calculations based on data from USDA, National Agricultural Statistics Service, 2013 Census of Agriculture.

Conclusion

A variety of options are available to farmers for adapting to drought risk. Few of these options will completely eliminate risk exposure, and almost all are constrained by existing institutional arrangements, public policies, and infrastructure investments. Drought adaptation includes not only irrigation but also tile drainage and measures to promote soil health.

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Chapter 3.17—Water Quality: Pollutants From Agriculture

David Smith, Stacy Sneeringer, and Maria Bowman

- According to the U.S. EPA's 2017 National Water Quality Inventory, 55 percent of assessed rivers and streams, 71 percent of lakes, and 84 percent of bays and estuaries nationally had impaired water quality as of 2016.
- The number of U.S. water bodies designated as impaired increased 40 percent between 2005 and 2016, due mostly to the completion of new assessments.
- An index of toxicity-weighted pesticide use, based on drinking water quality thresholds, has declined from 1992 to 2009, due primarily to restrictions on the use of a few pesticides.

The Nation's water is an important resource that is necessary for survival and well-being. We rely on it for drinking, to irrigate our crops, and as a source of food and recreation. When water is polluted it can become unsafe to use and expensive to clean. Agriculture is one of the largest sources of pollutants in the Nation's rivers, streams, and lakes. Before leaving the field, these pollutants (i.e., fertilizers, chemicals, and sediments) are important for producing food. As both pollutants and productive inputs, fertilizers, chemicals, and soils have both positive and negative effects on human well-being.

Under the Clean Water Act, water quality standards are set based on whether bodies of water are used for protection and propagation of aquatic life, for recreation, for public drinking water, and/or for other purposes. Water bodies not meeting these water quality standards are considered impaired and must have a pollution limit determined for them. Assessments, impairments, and pollution limits are reported to the U.S. Environmental Protection Agency (EPA) by the States as part of the National Water Quality Inventory.

Because of the uneven implementation of the Clean Water Act across State governments, assessing trends in water quality is difficult. As of 2016, 32 percent of rivers and streams, 44 percent of lakes, and 64 percent of bays and estuaries have been assessed for water quality (U.S. EPA, 2017).

Of those water bodies that have been assessed, 55 percent of rivers and streams, 71 percent of lakes, and 84 percent of bays and estuaries have impaired water quality; in short, the EPA determined that these 42,904 water bodies do not support their designated uses (e.g., fishing, recreation, and/or drinking water; EPA 2017). This is an increase of approximately 40 percent from 2005, when 25,823 water bodies were designated impaired. This increase in impairments is mostly due to the completion of new assessments of water bodies, therefore making it difficult to analyze trends in the number of water bodies that are polluted.

The largest causes of impairments in rivers and streams are sediments, nutrients, and pathogens. While these pollutants can come from other sources, according to the National Water Quality Inventory, agriculture is the largest source of impairments in rivers and streams and the second largest source in lakes and ponds.

Major Agricultural Pollutants

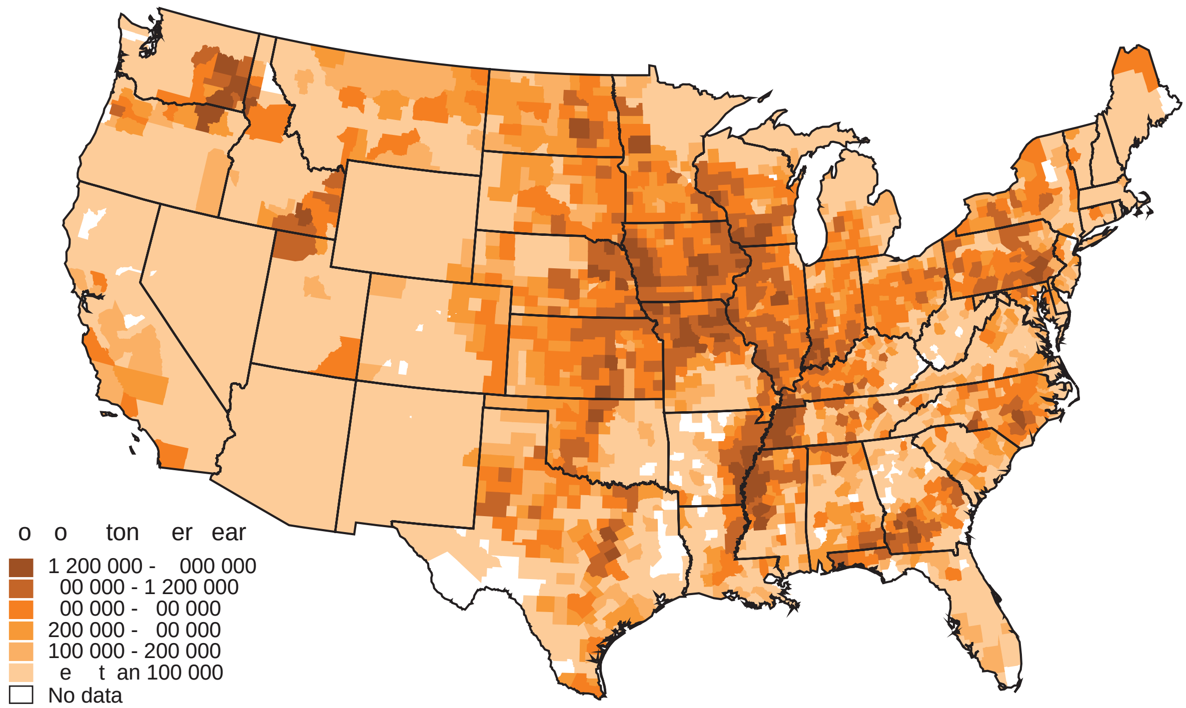
Sediment is the second largest cause of water quality impairments, just behind pathogens, in rivers and streams (U.S. EPA, 2017). Historically, much of this sediment was thought to be due to erosion on agricultural fields. In the 1980s and 1990s, however, erosion rates declined (see figure 3.19.3 in "Soil Health") due to improved cropping practices such as conservation tillage (see chapter 3.24, "Working-Lands Conservation Programs"). Cropping practices, such as tile drainage, also contribute to sediment

erosion within river and stream channels through increases in peak stream flow (Argabright et al., 1996; Zaimes et al., 2006; Belmont et al., 2011; Schottler et al., 2014). Agriculture is the largest source of impairments from sediment followed closely by within-channel sources (i.e., hydro modification and habitat alterations).

Significant sediment loss occurs in areas with high rates of water erosion and/or a high proportion of agricultural land (see chapter 1.2, "Major Land Uses"). Total sediment losses due to water erosion are highest in the Corn Belt and the Mississippi Delta due to the high proportion of land used for agriculture (figure 3.17.1). Field erosion rates are highest in the southeastern U.S. due to high precipitation and steep topography.

Figure 3.17.1

Soil loss (tons) by county due to water erosion, 2012



Source: USDA, Economic Research Service using data from the 2012 National Resources Inventory (USDA, 2012b).

Nitrogen and phosphorus are the second leading cause of impairments in lakes (mercury is the leading cause) and the third leading cause in rivers and streams (EPA, 2017). Excess nutrients can cause algal blooms, which can kill fish and other aquatic life. Algal blooms can even make people sick from the toxins produced and elevated bacterial levels. Nitrogen can also contaminate ground water. In agricultural areas, nitrate concentrations exceeded Federal drinking water standards in 20 percent of shallow domestic wells (Dubrovsky et al., 2010).

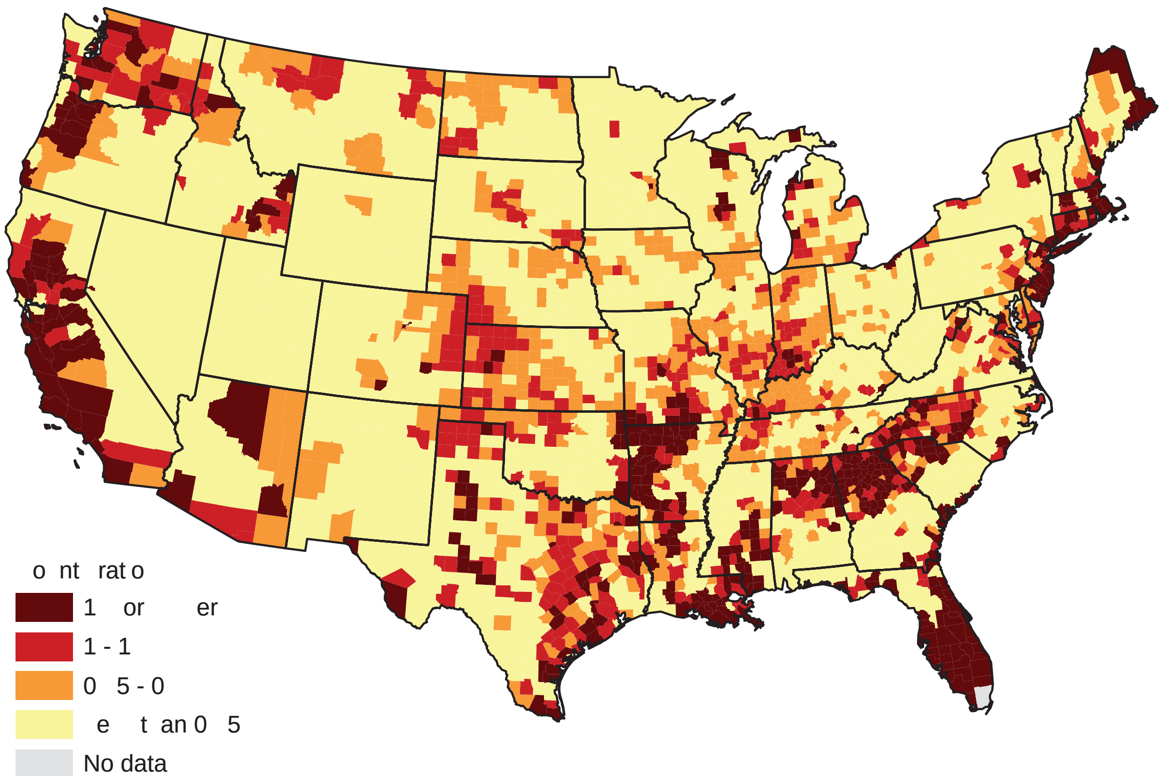
Crop farmers require these nutrients to grow their crops (see chapter 2.9, "Nutrient Management"), and often add nutrients to the soil by applying fertilizer or manure. While most nutrients are taken up by crops and pasture, nitrogen and phosphorus can leave the field or pasture and contaminate surface water through runoff and/or ground water through leaching. Sometimes farmers have leftover manure after applying enough to meet the nutrient needs of the crops. Farms with excess manure can transport or sell manure to other farms or businesses that can use or dispose of the manure (see chapter 2.14, "Manure

Management”). If there are many livestock in a region relative to cropland acreage, the risk of nutrient pollution from manure may be high.

Figures 3.17.2 and 3.17.3 show the ratio of the county-wide amount of available nutrients to the agronomically appropriate nutrient requirements for crops and pasture. Available nutrients include the amount of manure nutrients recoverable for later application to crops and pasture plus purchased commercial fertilizer. Values of the ratio greater than one suggest that farms within that county use more manure and fertilizer nutrients than are being taking up by crops and pastures, and therefore these counties exhibit a higher risk of nutrient runoff or leaching. The measure underestimates the risk of run-off, because it allows for recoverable manure nutrients to be applied off-farm within a county, instead of just on the farm where it is generated (see Gollehon et al., 2017, for estimates of farm-level excess). Other factors also contribute to run-off risk, including the prevalence of tile drainage, proximity to waterways, topographic features, and soil quality. Available nutrients tend to exceed agronomic cropland and pastureland needs in counties with high levels of manure from livestock production and little available cropland and pastureland.

Figure 3.17.2

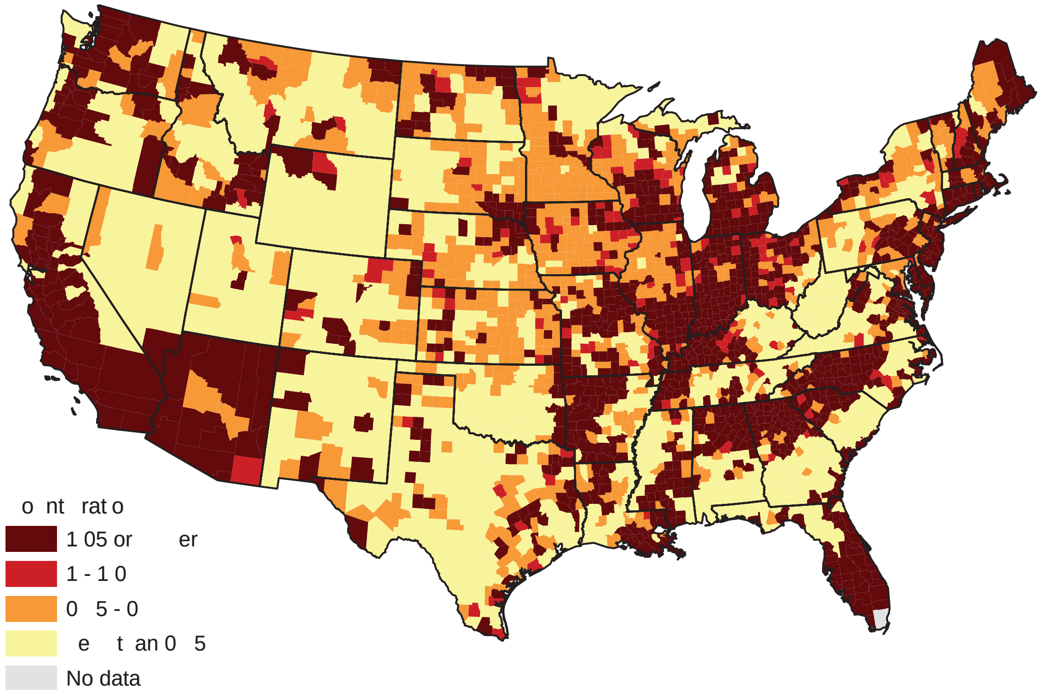
Ratio of nitrogen from commercial fertilizer and manure to crop/pasture uptake by county, 2012



Note: Ratio of recoverable manure and commercial fertilizer nitrogen to agronomically appropriate nitrogen requirements of crop and pasture land within a county.
Source: USDA, Economic Research Service using data from the 2012 Census of Agriculture (USDA 2012a).

Figure 3.17.3

Ratio of phosphorus from commercial fertilizer and manure to crop/pasture uptake by county, 2012



Note: Ratio of recoverable manure and commercial fertilizer phosphorus to agronomically appropriate phosphorus requirements of crop and pasture land within a county.
Source: USDA, Economic Research Service, using data from 2012 Census of Agriculture (USDA 2012a).

Under USDA, Natural Resources Conservation Service (NRCS) assumptions of "full" nutrient management, if 1.2 pounds of nitrogen are applied to a crop or pasture, 0.2 pound is either lost to the environment or returned to the soil as the non-harvested portion of the plant. Under "acceptable" nutrient management, if 1.4 pounds of nitrogen (1.05 pounds for phosphorus) are applied, then 0.4 pound is lost. In figure 3.17.2, counties with a ratio of nitrogen applications to uptake greater than 1.4 are at a higher risk for nutrient run-off even if only "acceptable" nutrient management is employed.

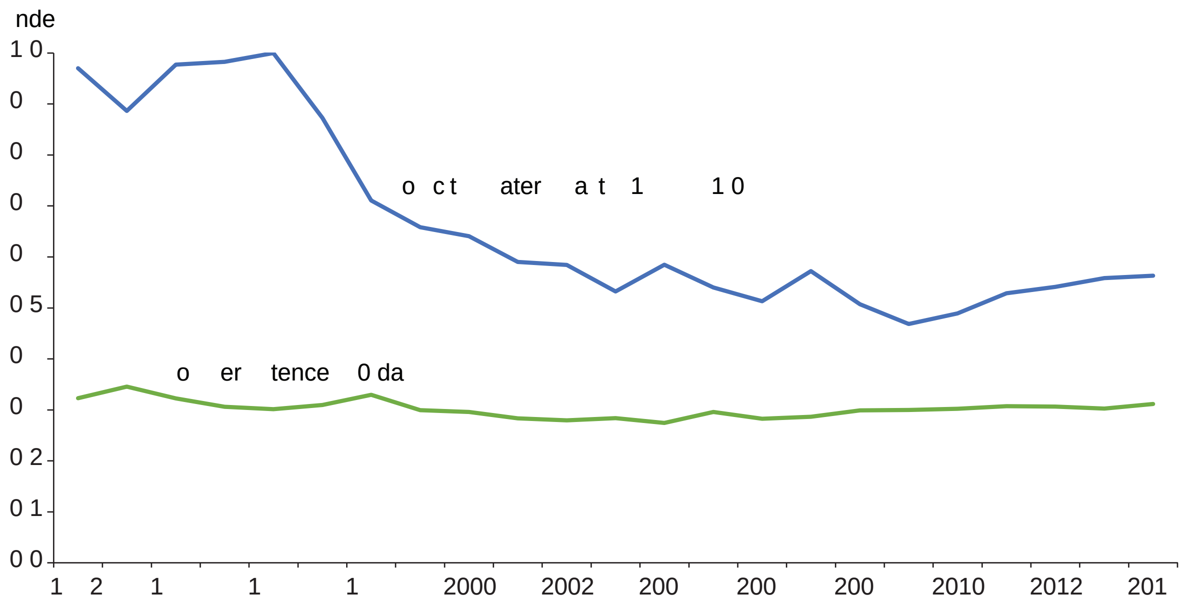
Farmers use **pesticides** to control insects (insecticides), weeds (herbicides), fungus (fungicides), and other pests (see chapter 2.8, "Pest Management"). In 2014, nearly 1 billion pounds of active ingredients were applied on U.S. cropland (USGS, 2017). Once applied, pesticides can remain in the soil for weeks, months, or years. On average about 30 percent of the pesticides applied remain in the soil after 60 days (figure 3.17.4). Persistent pesticides, with long half-lives, can travel off the field and into waterways where they may harm fish and other aquatic life.

Pesticides are the cause of over 1,800 impaired water bodies in the United States (EPA 2017). Agricultural pesticides that cause the most impairments are Dichlorodiphenyltrichloroethane (DDT), chlorpyriphos, and atrazine. DDT is an insecticide that was banned by the EPA in 1972 but persists in the environment for years. Chlorpyriphos is an insecticide used in the production of corn, orchards, and grapes. Atrazine is an herbicide used primarily in corn for weed control. Use of atrazine has ranged between 60 and 80 million pounds annually despite increases in the use of alternative herbicides such as glyphosate (USGS, 2017).

Pesticides may also contaminate ground water and well water. Pesticides were detected in 53 percent of groundwater samples but the levels seldom (1.8 percent of samples) exceeded drinking water quality benchmarks (Toccalino et al. 2014). In the 1990s, toxicity, as measured by an index based on drinking water quality thresholds, declined (Figure 3.17.4), primarily due to restrictions on the use of an insecticide primarily used in cotton production (parathion) and an herbicide primarily used in corn production (cyanazine). Higher toxicity from agricultural pesticides occurs in the Corn Belt due primarily to the continued use of atrazine on corn (figure 3.17.5). Fumigant use in fruit and vegetable production contributes to the high toxicity of pesticides used in the Southeast, California, and the Pacific Northwest.

Figure 3.17.4

Agricultural pesticide toxicity indexes using water quality thresholds and 60-day soil persistence, 1992-2014

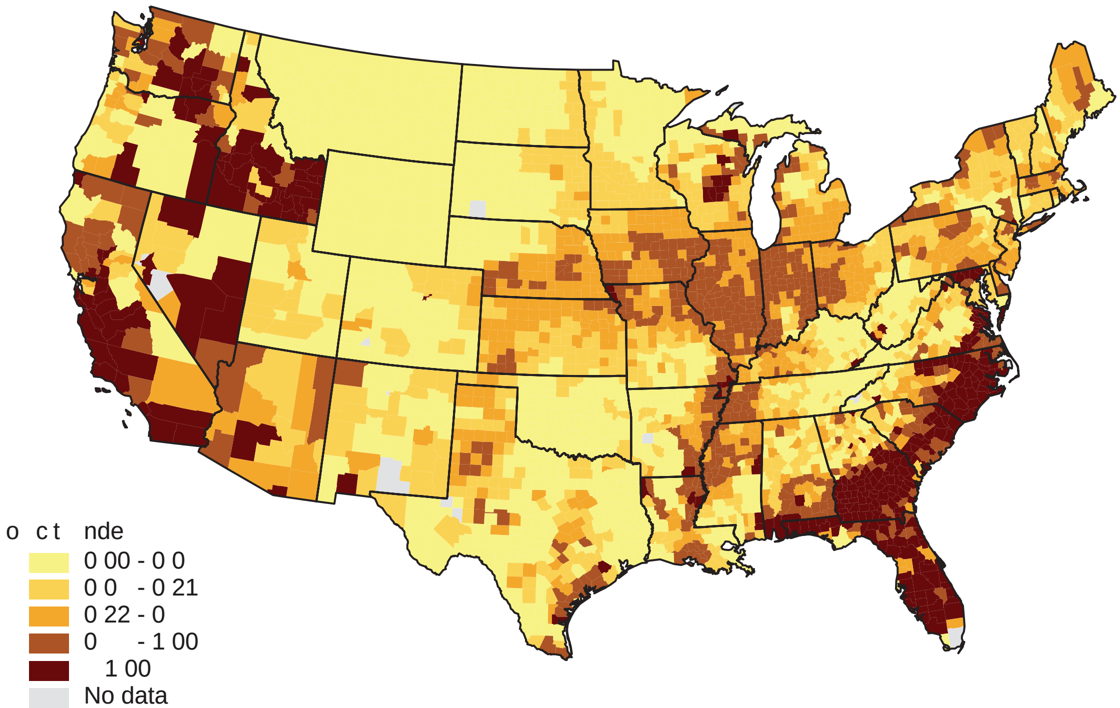


Note: The agricultural pesticide toxicity index is calculated by dividing the average pesticide usage (kilograms per acre) by the water quality threshold (parts per billion) for each active ingredient and then summing across all active ingredients. The index for toxicity is normalized so that the index equals 1.0 in 1996 and so only comparisons between years are valid. The index for the persistence of agricultural pesticides is the estimated average percentage of the initial application that is still in the soil at 60 days based on the soil half-life and the formula for exponential decay.

Source: USDA, Economic Research Service based on data from the U.S. Geological Survey (2017) and Fernandez-Cornejo (2014).

Figure 3.17.5

Agricultural pesticide toxicity index using water quality thresholds by county, 2014



Note: The agricultural pesticide toxicity index is calculated by dividing the average pesticide usage (kilograms per acre) by the water quality threshold (parts per billion) for each active ingredient and then summing across all active ingredients. This index is normalized so that it equals 1.0 for the average index per acre in 2014.
Source: USDA, Economic Research Service based on data from the U.S. Geological Survey (2017) and Fernandez-Cornejo (2014).

Following new guidance in 1996 from the EPA, the last two decades have been marked by a dramatic increase in the number of Clean Water Act assessments and the number of pollution limits. Since 2005, States have issued over 50,000 pollution limits, with two-thirds of river and stream miles, half of lakes, and a third of bays/estuaries still to be assessed. Agricultural sources of pollution are largely exempt from regulation under the Clean Water Act. Therefore, the Federal Government relies on voluntary conservation programs (see chapter 3.21, "Conservation Spending") and grants to States to reduce agricultural point and nonpoint sources. Of the water bodies that have been assessed and found to be impaired, only 5 percent have been restored enough to support their designated use.

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Chapters 3.18 (Renewable Energy) through 3.24 (Working Lands Conservation Programs) have been removed from this document.

Appendix: Data Sources

Chapter 1.1: Farm Numbers and Size	To follow long run trends in farm numbers, the chapter uses farm counts from the 1850 to 2012 Censuses of Agriculture. The 2012 census is the latest available; the 2017 census will be released during the spring of 2019. The chapter uses the 2017 Agricultural Resource Management Survey (ARMS) to examine farms by size of farm, measuring farm size by gross revenue. USDA's National Agricultural Statistics Service (NASS) is currently conducting the 2018 ARMS, for release in December 2019.
Chapter 1.2: Major Land Uses in the United States	This chapter relies nearly exclusively on data from ERS's Major Land Uses (MLU) data product, which provide the most comprehensive national accounting of land use in the United States. The data were most recently updated in August 2017 to provide information for 2012. There is one component of the MLU data that is updated annually for the Nation as a whole (cropland used for crops). The cropland used for crops data are presented in figure 1.2.3, along with other cropland uses that are not included in the annual update (cropland pasture and cropland idled).
Chapter 1.3: Farmland Values	The land values data come from NASS's June Area Survey. This data is updated annually and reported in NASS's Land Values summary report and Quick Stats database. The most recent update was released in August 2018.
Chapter 1.4: Farmland Ownership and Tenure	This chapter uses data from the 2014 Tenure, Ownership, and Transition of Agricultural Land (TOTAL) Survey. The TOTAL Survey constitutes the most recent effort (since 1999's Agricultural Economics and Land Ownership Survey) to provide comprehensive information on farmland ownership arrangements, landlord-tenant agreements, owner characteristics, and farmland acquisition and transfer plans.
Chapter 1.5: Agricultural Productivity and Sources of Growth in the U.S. Farm Sector	The productivity chapter draws data mainly from the ERS "Agricultural Productivity in the U.S." dataset, which was released October 2017. The U.S. productivity dataset provides estimates of total factor productivity (TFP) and prices and quantities of 10 outputs and 12 inputs in the U.S. farm sector for 1948-2015. The next updates are expected to be released in late 2019.
Chapter 1.6: Agricultural Research and Development	Data sources are Current Research Information System (USDA, National Institute of Food and Agriculture); Survey of Federal Funds for Research and Development (National Science Foundation, NSF); ERS compilations of data from multiple private sector sources following the methodology used in ERR-130; Business R&D and Innovation Survey (BRDIS—NSF). Public sector data are presented through 2015, the last year Federal Funds Survey data are available. Private sector data are presented through 2014, the last year for which data are available from BRDIS.
Chapter 2.7: Biotechnology, Seed Use, and Pest Control for Major U.S. Crops	Data from ERS's Agricultural Economic Report No. 810, the NASS June Area Survey (2000-2018), the U.S. Geological Survey's Agricultural Pesticide Use database (2000-2014), and a proprietary data source (1998-2017) were used to create the figures and tables in this chapter.
Chapter 2.8: Pest Management	Data are from several sources, including the U.S. Environmental Protection Agency, Pesticides Industry Sales and Usage report (2017); U.S. Geological Survey data on estimated annual agricultural pesticide use by crop group for conterminous States, and recent NASS QuickStats data (up to 2016). For some figures, proprietary data were used. Differences in the time periods discussed in chapters 2.7 and 2.8 stem from differences in the datasets analyzed.
Chapter 2.9: Nutrient Management	Data include USDA, Economic Research Service *Fertilizer Use and Price*, based on "Commercial Fertilizers 2014," published in July 2017; the latest commodity-specific Phase II surveys—corn, 2016; cotton, 2015; soybeans, 2012; and winter wheat, 2009.
Chapter 2.10: U.S. Irrigated Agriculture: Farm Structure, Technology, and Conservation	Data are from the 2012 Census of Agriculture, the 2013 Farm & Ranch Irrigation Survey (FRIS), and (to a lesser degree) the 2010 USGS Water Estimates report. No new irrigation/water data will be available until late 2019. Numbers will not be available from the 2017 Census of Agriculture until the spring of 2019. The 2018 FRIS went out into the field in January 2019, with data expected in late 2019. USGS is still working on its 2015 Water Estimates report (no expected date for release).

Chapter 2.11: Precision Agriculture	Data are from crop-specific ARMS surveys, conducted from 1996 to 2016. ARMS surveys are done annually, with 2017 information scheduled for release in the latter part of 2019. ARMS collects very detailed information on production practices and is conducted annually for one or two crops.
Chapter 2.12: Crop Production Management: Tillage Practices	No-till and strip-till adoption rates are estimated using the farm-level portion of the 2010 and 2011 ARMS and field-level ARMS for soybeans in 2012, cotton in 2015, corn in 2016, and wheat in 2017. The data are presented by crop and region. In the farm-level surveys, farmers were asked to report the acreage of corn, soybeans, wheat, and cotton where no-till/strip-till was used in the survey year. The 2010-11 farm-level surveys are the only farm wide ARMS tillage data available. In the field-level surveys, farmers' tillage use reflects the absence of tillage operations in the survey year; prior-year data are based on producer recall. Field-level ARMS are crop-year specific and conducted annually.
Chapter 2.13: U.S. Organic Farming Systems	Data on organic production are from USDA-ARMS surveys, including the 2006 ARMS soybean survey, 2007 ARMS apple survey, 2009 ARMS wheat survey, and 2010 ARMS corn survey; these ARMS commodity surveys contained targeted over-samples of organic producers to ensure statistically reliable data for production stratified by farming system. Data from the most recent (2012) Census of Agriculture and the 2014 National Organic Producer Survey follow-on census are also used, as is data from 2006-2016 from USDA's National Organic Program Integrity database. The most recent data from USDA's Natural Resources Conservation Service on conservation program (EQIP) funding for organic and transition practices—from 2009 (when funding for these practices was initiated) through 2016—are also used. Data on U.S. organic product market share are from the market research company IRI for the 2009-14 period, and data on U.S. organic retail sales are from the Nutrition Business Journal and Organic Trade Association through 2017.
Chapter 2.14: Manure Management	Figure 2.14.1 uses the 2012 Census; the 2017 Census will be released in the spring of 2019. Tables 2.14.1 and 2.14.2 use the 2009 hog, 2010 dairy, and the 2011 broiler surveys. The broiler survey is the latest available, with no date set for a future survey. More recent hog and dairy surveys (2015 hogs, 2016 dairy) do not ask detailed questions about manure handling (e.g., how the manure was applied, whether and how it was removed, whether the operation has a nutrient management plan, whether the operation adjusted manure nutrient content via feed, or whether the farm received EQIP payment for manure management), and so were not used.
Chapter 2.15: Antibiotic Use in U.S. Livestock Production	Data on broilers raised without antibiotics except for disease treatment are from the 2006 and 2011 ARMS broiler surveys. The 2011 broiler survey is the latest available, with no date set for a future survey. The 2017 statistic on broilers produced under product lines termed "raised without antibiotics" is from USDA AMS Agricultural Analytics. Data from the 2004, 2009, and 2015 ARMS hog surveys are used to estimate the percentage of hogs that were administered antibiotics for growth promotion; the 2015 hog survey is the latest available. Statistics quoted from APHIS's National Animal Health Monitoring System (NAHMS) use the most recent surveys available.
Chapter 3.16 Farm-Level Adaptation to Drought Risk	Data on crop insurance and drought comes from USDA, Risk Management Agency's publicly available "Summary of Business – Cause of Loss" files and is adjusted using ERS farm-income data. Data for the drought risk measure come from publicly available National Oceanic and Atmospheric Administration (NOAA) Palmer Drought Index historical data from 1900 to 2016. The data on irrigated cropland are from the Census of Agriculture publicly available county-level data and are up to date (1998-2013). The tile drainage map is from a special requested dataset from NASS from the 2012 Census of Agriculture.
Chapter 3.17: Water Quality: Pollutants From Agriculture	Data are from the 2012 Census of Agriculture and the USGS Pesticide National Synthesis Project (1992-2014). We also use the EPA 2017 Water Quality Assessment. The most recent USGS Pesticide National Synthesis Project data are available for 2015. We choose not to use the 2015 data because there was a major shift in methodology in 2015. Starting in that year, no data on seed treatments were reported.

Chapter 3.18: Renewable Energy	Data are from the 2012 Census of Agriculture for estimates of the share of farms with on farm renewable production systems. These are the most recent data available, as ARMS does not ask about renewable production systems. Additional data are from the 2014 ARMS, since that survey asked about royalty income from wind leases. In later ARMS surveys, it is not possible to disentangle wind lease income from oil/gas royalty income. Data on biofuel production are from 2018 updates to ERS' U.S. Bioenergy data and EIA's Monthly Energy Review.
Chapter 3.19: Soil Health	Data are from the 2012 Census of Agriculture, the 2015 Agricultural Resource Management Survey, administrative data on programs administered by the USDA Natural Resources Conservation Service, and the 2012 NRCS National Resources Inventory (NRI). Administrative data–from 2015 and 2016–on EQIP and CSP program acreages and expenditures are the most recent data provided to ERS by NRCS. Census of Agriculture data are some of the most geographically comprehensive data on adoption of soil health and conservation practices in the United States. Updated NRI data, for 2017, are likely to be released in 2019.
Chapter 3.20: Pollinators: Honey Bee Status and Trends	The pollinator chapter uses data from the annual USDA/NASS Honey Report; using the 2018 version containing data for 2017 available at time of publication. USDA/NRCS National Resources Inventory data, from 1982 to 2012 (the most recent year available) are also used.
Chapter 3.21: Conservation Spending Seeks To Improve Environmental Performance in Agriculture	Data on conservation program spending run through fiscal year 2017. These data are updated annually based on the USDA budget summary released, along with the President's budget. The figure, Conservation Program Spending, Fiscal Years 1996-2017, is updated on the ERS conservation programs topic page annually.
Chapter 3.22: Wetlands: Status and Trends	This chapter uses National Resources Inventory summary data (USDA/NRCS (2015)). Wetlands Reserve Program contract acreage and financial obligations were taken from a 2017 USDA/NRCS report, as were details on the Agricultural Conservation Easement Program (ACEP) wetland acreage and obligations. Details on CRP wetlands are derived from 2018 USDA/FSA reports on the CRP. These data sources are updated periodically; the studies used here were the latest available when this chapter was drafted.
Chapter 3.23: Conservation Reserve Program	Data are from reports regularly produced by the USDA Farm Service Agency (FSA). In addition, historical trend data are based on yearly contract data from FSA, the most recent being from the end of fiscal year 2017 (September 30, 2017). Also, FSA offer data from CRP's general signups (1996-2016) are used.
Chapter 3.24: Working-Lands Conservation Programs	Data on EQIP participation are from the 2016 ARMS Phase 3 survey. The data on program expenditures are publicly available and are through 2016. The data on resource concerns are from an ERS analysis of the 2011 to 2013 NRCS ProTracts database.